

## Workforce planning models for oral healthcare: A scoping review

O'Malley, Lucy; Macey, Richard; Allen, Thomas; Brocklehurst, Paul; Thomson, Francesca; Rigby, Janet; Lalloo, Ratilal; Tomblin, Gail; Birch, Stephen ; Tickle, Martin

**JDR Clinical & Translational Research**

DOI:

<https://doi.org/10.1177%2F2380084420979585>

Published: 01/01/2022

Publisher's PDF, also known as Version of record

[Cyswllt i'r cyhoeddiad / Link to publication](#)

*Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):*

O'Malley, L., Macey, R., Allen, T., Brocklehurst, P., Thomson, F., Rigby, J., Lalloo, R., Tomblin, G., Birch, S., & Tickle, M. (2022). Workforce planning models for oral healthcare: A scoping review. *JDR Clinical & Translational Research*, 7(1), 16-24.  
<https://doi.org/10.1177%2F2380084420979585>

### Hawliau Cyffredinol / General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

## REVIEWS

# Workforce Planning Models for Oral Health Care: A Scoping Review

L. O'Malley<sup>1</sup>, R. Macey<sup>1</sup> , T. Allen<sup>2</sup>, P. Brocklehurst<sup>3</sup>, F. Thomson<sup>1</sup>, J. Rigby<sup>4,5</sup>, R. Lalloo<sup>6</sup> , G. Tomblin Murphy<sup>4,5</sup> , S. Birch<sup>7</sup>, and M. Tickle<sup>1</sup>

**Abstract: Background:** For health care services to address the health care needs of populations and respond to changes in needs over time, workforces must be planned. This requires quantitative models to estimate future workforce requirements that take account of population size, oral health needs, evidence-based approaches to addressing needs, and methods of service provision that maximize productivity. The aim of this scoping review was to assess whether and how these 4 elements contribute to existing models of oral health workforce planning.

**Methods:** A scoping review was conducted. MEDLINE, Embase, HMIC, and EconLit were searched, all via OVID. Additionally, gray literature databases were searched and key bodies and policy makers contacted. Workforce planning models were included if they projected workforce numbers and were specific to oral health. No limits were placed on country. A single reviewer completed initial screening of abstracts; 2

independent reviewers completed secondary screening and data extraction. A narrative synthesis was conducted.

**Results:** A total of 4,009 records were screened, resulting in 42 included articles detailing 47 models. The workforce planning models varied significantly in their use of data on oral health needs, evidence-based services, and provider productivity, with most models relying on observed levels of service utilization and demand.

**Conclusions:** This review has identified quantitative workforce planning models that aim to estimate future workforce requirements. Approaches to planning the oral health workforce are not always based on deriving workforce requirements from population oral health needs. In many cases, requirements are not linked to population needs, while in models where needs are included, they are constrained by the existence and availability of the required data. It is critical that information systems be

developed to effectively capture data necessary to plan future oral health care workforces in ways that relate directly to the needs of the populations being served.

**Knowledge Transfer Statement:**

Policy makers can use the results of this study when making decisions about the planning of oral health care workforces and about the data to routinely collect within health services. Collection of suitable data will allow for the continual improvement of workforce planning, leading to a responsive health service and likely future cost savings.

**Keywords:** health planning, health workforce, dental staff, dental health services, health resources, health services needs and demand

**Introduction**

Effective planning of the health care workforce is essential to ensure that health care systems work efficiently and are sustainable in the long term and if

DOI: 10.1177/2380084420979585. <sup>1</sup>Division of Dentistry, School of Medical Sciences, University of Manchester, Manchester Academic Health Sciences Centre, Manchester, UK; <sup>2</sup>Centre for Health Economics, University of Manchester, Manchester Academic Health Sciences Centre, Manchester, UK; <sup>3</sup>NWORTH Clinical Trials Unit, University of Bangor, Bangor, UK; <sup>4</sup>WHO/PAHO Collaborating Centre on Health Workforce Planning and Research, Dalhousie University, Halifax, Canada; <sup>5</sup>Research, Innovation and Discovery, Nova Scotia Health Authority, Halifax, Canada; <sup>6</sup>School of Dentistry, The University of Queensland, Brisbane, Australia; <sup>7</sup>Centre for the Business and Economics of Health, Faculty of Business Economics and Law, The University of Queensland, Brisbane, Australia. Corresponding author: L. O'Malley, Division of Dentistry, School of Medical Sciences, University of Manchester, Manchester Academic Health Sciences Centre, Coupland 3, Oxford Road, Manchester, M13 9PL, UK. Email: lomalley@manchester.ac.uk

A supplemental appendix to this article is available online.



Article reuse guidelines: sagepub.com/journals-permissions

© International & American Associations for Dental Research 2020

policy aims for universal health coverage are to be met. Failure to plan effectively can result in problems with 1) access to services and inability to address unmet needs in the population; 2) degradation of the quality of care and increased risks to patient safety; 3) low staff morale and concerns about staff retention; and 4) poor stewardship of health care budgets, as expenditures on workforce can account for around 70% of health system budgets.

Workforce planning (WFP) for health care is different from other labor markets, which are determined by “market forces” where the demand for labor is derived from the goods and services that consumers demand. If health care WFP were to be left solely to market forces, the resulting workforce capacity would reflect individuals’ willingness and ability to pay for care, as opposed to needs for care in the populations, resulting in social inequalities in access to care and a failure to maximize population health improvement (McPake et al. 2013). Unlike other labor markets, demand for health care is not independent of supply (Birch et al. 2017) because suppliers influence demand for care. Due to the complexity of health care and imbalance of knowledge between consumer (patient) and supplier, consumers are reliant on the advice of health care professionals for the care that they receive, but suppliers are influenced by their own constraints and opportunities in determining what care to provide (Arrow 2004). For example, where primary care dentists operate as independent small businesses, the provider’s priority is the financial well-being of the practice. As a result of these concerns about how labor markets work in health care, as well as the high cost and long periods of training required to produce health workers, government intervention is usually required in planning the health care workforce (McPake et al. 2013).

Traditional approaches to WFP in dentistry have tended to be inflexible and disconnected from the strategic and financial planning of oral health

care services (Brocklehurst and Tickle 2012). At its most simple, health WFP has used a “stock and flow” model to estimate the supply or availability of oral health care workers, produce new health care workers to replace those who retire or leave the service, and respond to anticipated changes in demands for care. Whether this supply is expected to be sufficient is determined by estimates of future demand. This has been based largely on applying forecasted changes in demography (the size and age distribution of the population) to the current levels of provider supply or service utilization. The former is measured by the ratio of clinicians to the size of the population—for example, numbers of patients registered with dental practices per 1,000 population. The latter is measured by the ratio of services used to the size of the population—for example, numbers of extractions per 1,000 population. This simplistic approach ignores other vital factors, such as the changing health care needs of the population served (Gallagher et al. 2015), the type or level of services offered by the health care system, and the rate of service production (or provider productivity; Gallagher et al. 2013). All of these have major influences on the numbers and types of health care workers required by the health care system aimed at meeting the oral health needs of the population, and none of these are expected to be constant over time (Ahern et al. 2019).

These traditional models of WFP contain the implicit assumption that population needs and models of care are constant across different populations and over time. Using this approach, planners run the risk of perpetuating current planning inefficiencies (e.g., unmet need for care, overutilization of services; Birch et al. 2017) and potentially making the situation worse in the future, as changes in population need move further away from current service provision. In this way, current models might be described as projecting the present, as opposed to planning the future.

Birch et al. (2007) recommended a needs-based model for WFP to address the deficiencies of traditional demographic-based models (i.e., models where only the size and age distribution of the population change). In this approach, ratios of provider or utilization to population are variable and determined by 1) health care needs and risks; 2) the level of service that policy makers plan to provide for different risk groups in the population; and 3) the productivity of the workforce associated with the models of service delivery to be used, taking into account opportunities for alternative skill mix. The needs-based model also has the benefit of intrinsically linking service planning to WFP. Workforce requirements are derived directly from the estimated need for services, enabling planners to have unified oversight of health care system budgets.

Application of this need-based model requires data to be collected periodically and consistently on the needs of the population, not merely the services provided to patients (Gallagher et al. 2013). This has obvious resource implications and might be a reason why less sophisticated approaches to WFP are still adhered to. In the field of oral health care, we have a poor understanding of how WFP is conducted globally and whether needs-based models are being used or if traditional models with all of their limitations remain the norm. The aims of this review were to identify and describe how different WFP models determine the requirements for oral health workers and whether these models are responsive to changes in health needs of populations and evidence-based approaches to addressing those needs and producing those services. Hence, the article focuses on reviewing the structure of the models, not the estimated requirements or demands for dentists that they produce.

## Methods

Scoping reviews allow for an iterative approach (Levac et al. 2010)

to searching, which was deemed most appropriate given the need to include gray literature databases. Additionally, the review question was broad and required a scoping approach rather than a focused systematic review, and the models to be included were expected to be highly varied in how they were reported and what they included.

We sought to identify all models used to assess future oral health care workforce requirements (or “demands”). This included oral health care workers from primary and secondary care settings and covered dentists, dental nurses, dental hygienists, and dental specialists. All types of study design were considered for inclusion if they met the selection criteria. WFP models were defined as any quantitative method designed to assess future workforce requirements for the purposes of informing WFP. No limits were placed on language or country; literature published prior to the year 2000 was excluded to keep results most relevant. A working protocol was developed but not registered; it is available from the contact author upon request.

A comprehensive search was undertaken to identify published and unpublished reports of studies that use, or describe the development of,  $\geq 1$  models to estimate future workforce requirements. The search strategy was devised with the help of a librarian who, with the review team, worked to identify a list of free text and controlled vocabulary. The strategy was tailored for searches on the following electronic databases: MEDLINE, Embase, HMIC, and EconLit, all via OVID. The search strategy for MEDLINE via OVID can be seen in Appendix Table 1. The search covered the period of January 2000 to January 2019. In addition, key bodies and policy makers, such as the World Health Organization (WHO), World Dental Federation (Fédération Dentaire Internationale [FDI]), and chief dental officers, were contacted to seek unpublished models, and a number of gray literature databases were searched: Grey Literature, OpenGrey,

International Labour Organisation, and National Health Service (evidence search).

### Eligibility for Inclusion of Studies

- A quantitative model for estimating current and future health needs and/or workforce requirements
- A model specific to oral health, dental health providers, or dental services
- Any country
- Published in or after the year 2000
- Any study design (excluding editorials/opinion pieces)

### Assessment of Relevance

In keeping with scoping review methodology, the relevance of the identified references was established iteratively (Levac et al. 2010). Once the electronic searches had been carried out, search results were initially screened by a single reviewer (L.O.), and obviously irrelevant records were discarded at this point. The second round of screening was carried out by independent reviewers (L.O., R.M., F.T.), and discrepancies were solved via discussion. Full texts were sought for all records marked *include* or *unclear*. All full texts were brought into the data extraction stage.

Data extraction was completed by a single author (L.O.). Data extraction was completed through structured forms developed and piloted by the wider review team before use. Data extracted included

- Geographic location where the model was used and health care system in place
- Population characteristics relevant to model
- Clinical focus of the model
- Model characteristics and mode of measurement of model parameters (population risks, supply, demand, need, services per need, productivity)

### Synthesis

A narrative synthesis was conducted. Due to the focus on models as

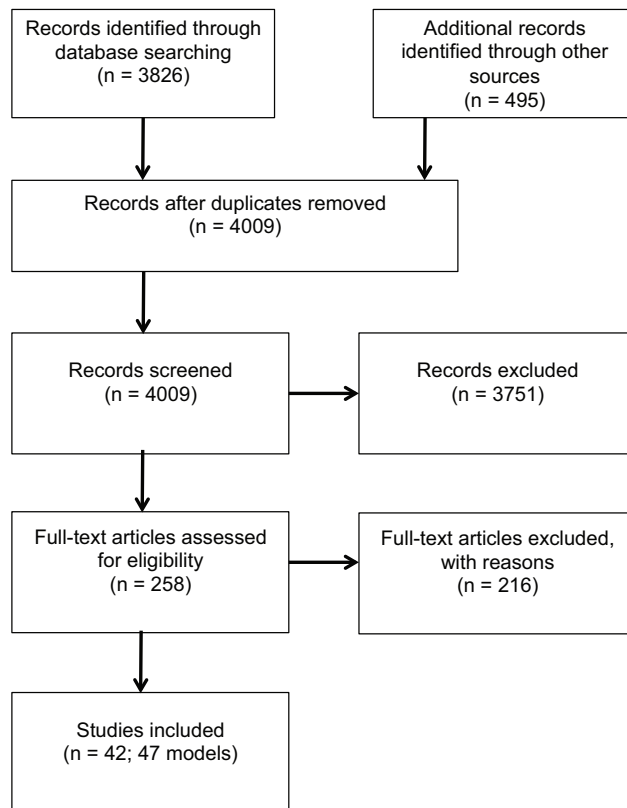
opposed to estimated numbers and the diverse nature of the included studies, particularly in terms of study design, quantitative synthesis was not relevant for this review. Instead, a synthesis was conducted by model type.

### Results

The PRISMA diagram outlining the research results is presented in the Figure. Initial screening led to the exclusion of 3,751 records, leaving 258 for double screening. This process resulted in 216 records being excluded, leaving 42 for which the full text was sought. Four of these articles described  $>1$  model, resulting in 47 models that met all inclusion criteria.

### Characteristics of Included Studies

Geographically, WFP models were most commonly from the United States ( $n = 11$ ), the United Kingdom ( $n = 8$ ), and Australia ( $n = 3$ ). The remaining models were from a range of countries covering Canada and South America, Europe, the Middle East, and the Far East. Notably, no models were identified as being used in Africa. The majority of models focused on general populations and general oral health. Three models included some provision for workforce across urban and rural areas, offering the potential for separate estimates of requirement by area and thereby recognizing the differences between urban and rural circumstances. Of the 47 models, most ( $n = 39$ ) focused on the general population (3 children only, 5 adult only) and general oral health care ( $n = 41$ ); 2 models were concerned with periodontics, 2 prosthodontics, 1 orthodontics, and 1 oral surgery. A number of models focused on supply and considered demand only in terms of population size ( $n = 11$ ); 11 models examined estimating demand through service utilization levels. Twenty-four models linked demand with population health needs, and 18 models considered building in workforce productivity. Detailed characteristics of included studies are presented in Appendix Table 2.

**Figure.** Flow diagram showing results of the literature search.

## Supply and Demand

### Population

A number of models ( $n = 11$ ) were most focused on projecting numbers based on supply of dentists (Ahmed et al. 2000; Lexomboon and Punyasingh 2000; Tira et al. 2003; Teusner and Chrisopoulos 2008; Guthrie et al. 2009; Al-Jarallah et al. 2010; Cartes-Velásquez 2013; Huang et al. 2013; Gallagher et al. 2015; US Department of Health and Human Services 2015; Shaw et al. 2017). All these models centered on dentists rather than other oral health care workers, and generally staff numbers were the units of estimate rather than whole time equivalent, except for 2 (Huang et al. 2013; Shaw et al. 2017). The models tended to include an estimate of demand, but this was generally limited to population numbers so that projected supply could be compared with population size as a provider:population ratio. An arbitrary ratio was sometimes

used (Ahmed et al. 2000; Tira et al. 2003); otherwise, ratios were based on historical patterns (Al-Jarallah et al. 2010; Cartes-Velásquez 2013) or in line with WHO recommendations or those of other countries or regions (Gallagher et al. 2015). While a number of these models were from settings in which data availability might be limited (Ahmed et al. 2000; Al-Jarallah et al. 2010; Cartes-Velásquez 2013; Gallagher et al. 2015), 4 models were developed in the United States and 1 in Australia. The advantage of these models lies in their single focus and simplicity. These models tend to be transparent and easy to apply and understand, and, importantly, they can be used when there are limited data available about demand and need. Supply has been estimated in a number of ways across these models, most commonly through estimating inflow (numbers of dentists coming into the workforce; e.g., student numbers, immigration) and outflow (those leaving;

e.g., retirement, career breaks, migration, death). In 1 model, the number of female dentists entering the workforce was highlighted as a potential for reduction in supply of services due to assumptions, as opposed to evidence, around intentions to work on a part-time basis (Guthrie et al. 2009). In 1 model, the current workforce was surveyed (Huang et al. 2013) to estimate whole time equivalent.

### Utilization

Eleven models included different ways to estimate demand, notably by measures of utilization (Beazoglou, Bailit, and Heffley 2002; Beazoglou, Heffley, et al. 2002; Byck et al. 2002; NHS Education for Scotland 2008; Advisory Committee on Medical Manpower Planning 2011; Oh 2011; National Leadership and Innovation Agency for Healthcare 2012; Gallagher et al. 2013; Health Workforce Australia 2014; American Dental Association Health Policy Institute 2017; Bailit 2017). This brings in complications because utilization is not necessarily closely correlated with need and hence extrapolates current levels of overutilization while planning for continuing levels of unmet need. However, in the majority of these models, population estimates are considered alongside utilization patterns. Utilization of services is only a proxy of demand, in some cases measured through payment systems (Beazoglou, Heffley, et al. 2002) and/or past and present patterns of service use (NHS Education for Scotland 2008; Advisory Committee on Medical Manpower Planning 2011; Oh 2011; National Leadership and Innovation Agency for Healthcare 2012; Health Workforce Australia 2014; Harper et al. 2015; American Dental Association Health Policy Institute 2017; Bailit 2017) with the assumption that current patterns and levels of use will continue in the future at the same per capita rates by age group.

### Demand Linked to Need

Twenty-four models linked demand estimates to population health needs. This was attempted in different ways—



for example, 8 models attempted to measure the clinical need of a subset of the population (Royal College of Surgeons of England 2005; Bourne and Sa 2012; Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015; Shaw et al. 2017) to estimate need across the wider population. In some cases, generalization of the data was appropriate due to the populations of interest being small in the first place (Bourne and Sa 2012; Shaw et al. 2017), whereas in 4 models, clinical examinations were taken of university staff and would have been difficult to generalize beyond this (Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015). A similar end was achieved from existing population health data sets (Cooksey and Byck 2000; Lexomboon and Punyasingh 2000; Try 2000; Spencer et al. 2003; Department of Health 2004; Doughan et al. 2005; Gallagher et al. 2010; Saman et al. 2010; Department of Health and Higher Education Funding Council for England 2012; De Silva 2012; Gallagher et al. 2013; Vundavalli 2014; Wanyonyi et al. 2015; Jäger et al. 2016; Schwendicke et al. 2016; Cao et al. 2017). Making use of existing data sets may be the sensible choice in terms of resources; however, it may not be an appropriate choice. Two models were reported to have used data from the 12-y-old DMFT surveys (epidemiologic data of decay experience) and extrapolated these out across the whole population (Doughan et al. 2005; Vundavalli 2014).

A small number of models went further than just examining clinical need and considered sociodental need (Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015) and perceived need (Bourne and Sa 2012). Sociodental need was measured through a series of patient-reported measures. Two studies compared different types of needs assessments (clinical vs. sociodental need) to determine the number of dental staff required. The model containing the sociodental needs estimated a lower required number of staff. “Perceived

need” referred to the perception of the need for orthodontic treatment by children across Trinidad. Notably a model developed by the WHO and FDI was used in 4 studies (Lexomboon and Punyasingh 2000; Doughan et al. 2005; De Silva 2012; Vundavalli 2014) taking place in Lebanon, Sri Lanka, Thailand, and India. Systems dynamics models were applied in 3 studies (Lexomboon and Punyasingh 2000; Department of Health and Higher Education Funding Council for England 2012; De Silva 2012), in Sri Lanka, Thailand and England. A major limitation in all these approaches to incorporating need is that current or recent “snapshots” of oral health levels are used, which are unlikely to be good estimates of future need. Cohort methods can be used to help identify and predict changes in need over time and prepare for epidemiologic transitions in population health arising from the lived experiences of current cohorts (Whittaker et al. 2016).

### Workforce Productivity

The productivity of the workforce was considered to be a factor related to the number of workers needed in 29 of the included models (Cooksey and Byck 2000; Try 2000; Beazoglou, Bailit, and Heffley 2002; Beazoglou, Heffley, et al. 2002; Byck et al. 2002; Spencer et al. 2003; Department of Health 2004; NHS Education for Scotland 2008; Teusner and Chrisopoulos 2008; Guthrie et al. 2009; Gallagher et al. 2010; Department of Health and Higher Education Funding Council for England 2012; De Silva 2012; National Leadership and Innovation Agency for Healthcare 2012; Gallagher et al. 2013; Huang et al. 2013; Health Workforce Australia 2014; Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015; Harper et al. 2015; Shaw 2015; US Department of Health and Human Services 2015; Wanyonyi et al. 2015; Jäger et al. 2016; Schwendicke et al. 2016; Cao et al. 2017). In 10 models, expected treatment times were calculated by clinical estimates of how long the treatment would take (based

on needs estimates; Cooksey and Byck 2000; Department of Health 2004; De Silva 2012; Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015; Shaw 2015; Cao et al. 2017) or by data from health insurance records (Jäger et al. 2016; Schwendicke et al. 2016). In 4 models, estimates of productivity were based on surveys of time worked by dental staff (Byck et al. 2002; Spencer et al. 2003; Teusner and Chrisopoulos 2008; Huang et al. 2013). In 1 model (Beazoglou, Heffley, et al. 2002), productivity was measured in terms of dollars, which, among other issues, assumes that costs remain constant.

Thirteen models considered productivity in the context of the whole dental team (NHS Education for Scotland 2008; Gallagher et al. 2010; Advisory Committee on Medical Manpower Planning 2011; Department of Health and Higher Education Funding Council for England 2012; National Leadership and Innovation Agency for Healthcare 2012; Gallagher et al. 2013; Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015; Harper et al. 2015; US Department of Health and Human Services 2015; Wanyonyi et al. 2015).

Eight of these models produced a series of scenarios demonstrating the impact of using skill mix to increase dental team productivity (Gallagher et al. 2010; Advisory Committee on Medical Manpower Planning 2011; Gallagher et al. 2013; Ab-Murat, Sheiham, Tsakos, and Watt 2015; Ab-Murat, Sheiham, Watt, and Tsakos 2015; Harper et al. 2015). Three studies used scenario models to show different projections of productivity based on estimates of different increases in productivity or no increase (Guthrie et al. 2009; Oh 2011; Health Workforce Australia 2014).

### Discussion

This is the first review in the literature of how oral health WFP is approached across the world. It is therefore useful to policy makers and academics in providing a comparative understanding

of what methods are currently employed and where. We find diversity in the methods used for WFP, perhaps demonstrating a lack of coherence in how best to approach this important requirement. This lack of agreement on the most effective means to model future workforce requirements is demonstrated by the finding that numerous approaches are being used—often within the same country. There is also a concern that many high-need populous countries, most notably in Africa, have little visible evidence of a structured approach to oral health WFP. The most frequently used approach is to rely on traditional models based on current levels of supply and/or utilization. Very few models used a needs-based approach and linked service planning to WFP.

This study used systematic methods to conduct a scoping review and a multidisciplinary, multinational team conducted the review. While a scoping review was appropriate for this broad review question and a robust approach was used to contacting international bodies and policy makers to unearth gray literature on WFP, inevitably there is a danger that the data collected for this review will be incomplete, particularly as many of the WFP methods used by policy makers will not appear in the academic literature or be readily accessible through internet searches. However, the review does provide an overview of commonly used models and can be updated as research in this field progresses. A further limitation of this review is that we were not able to provide a systematic critical appraisal of included studies. This was due to the highly diverse nature of these models as well as there being no preexisting critical appraisal tool for such models.

We acknowledge that in many parts of the world a market-driven model is firmly embedded in the delivery of dental care. In a situation with privately financed dental schools and privately funded health care as the predominant actors in a system, policy makers might query why a robust approach to workforce and service planning is

required. But even in the least regulated free market health care systems, publicly funded services are still provided for vulnerable population subgroups (e.g., children), offering a safety net service for the most disadvantaged individuals as well as for specific groups such as armed services and veterans. There is also the need to recognize that public funds are used to subsidize private purchases of health care, often through tax offsets. Therefore, there is a strong case for the oral health care workforce to be planned effectively and efficiently through evidence-based methods if policy aims are to be met and public funding is to be spent wisely.

We found that the majority of models rely on continuous replacement of the current workforce with expansion of supply to match population growth. Also commonplace were models attempting to meet the demands of those consumers already accessing the system, thereby ignoring any unmet need. This approach is inflexible and risks perpetuating the inherent problems of poor access, degradation of quality, low staff morale, and inadequate financial planning. Furthermore, many models implicitly assumed that current supply levels are optimal and therefore locked in, potentially increasing future inefficiencies as a result. Very few models took into account the estimated needs of the future population that the workforce was being planned to serve. Furthermore, the majority of the models focused on estimating the numbers of dentists required rather than other members of the dental team, even though dentists' productivity will be dependent on the availability of other oral health workers.

A key stumbling block to a needs-based approach to planning is likely to be lack of high-quality data on need. This could be due to concerns about the costs of epidemiologic surveys to measure population need. However, this concern is likely to be misguided when considering 1) the very high costs of inaccurate WFP through excessive training and education costs and 2) the risks of

overutilization within a population owing to oversupply or having to rapidly implement costly short-term fixes to manage crises of undersupply. There are also theoretical and logistical challenges in how to measure need and how this measurement translates to the workforce requirements on the supply side. However, using observed demand cannot be justified; measuring the wrong concept well (demand) is no substitute for measuring the right concept imperfectly (need). Reliance on demand or service utilization data omits consideration of unmet needs and potential overutilization, thus perpetuating any existing inefficiencies and inequities into a model used to estimate of future workforce requirements. There is a significant need for international academic collaboration to develop new, more affordable methods of reliably measuring population oral health needs and also to establish the evidence base for methods to predict the numbers and types of oral health care workers required to provide a service for different levels of need.

Innovation in health care is usually considered as developing new technologies to prevent or treat disease, and the pursuit of these new technologies is usually advocated to improve health and/or reduce the costs of health care. The idea of applying innovation to WFP should also be thought of in this way, as a means of reducing unmet need and health inequalities, improving quality and effective management of resources, as well as maintaining sustainability of health care systems. A needs-based approach to WFP, especially where it is accompanied by an evidence-based approach to determining the types and levels of services provided and maximizing provider productivity, should be seen as an important innovation that can support health system transformation and improvements in the effectiveness and efficiency of health care systems. As such, WFP research should have greater prominence in government-funded research programs. Without

such innovation in planning, we risk failing to realize the potential gains from technological change, evidence-based practice, and improvements in understanding the social determinants of health.

Implementing a needs-based planning model is not without its challenges. This approach must be data driven and primarily requires data on the needs of the population, evidence-based care pathways, and productivity. It is unlikely that “perfect” data will be immediately available for each element of an integrated needs-based model. A first step would be to obtain an agreed understanding of how systems can benefit from a needs-based approach and what data are required to inform WFP and policy. Implementation is most likely to be incremental, where there is a gradual move toward the ideal data requirements. For example, an incorporation of simple (even self-reported) dental needs data within national or regional population health surveys would be a useful first step.

National and international bodies such as the WHO and FDI can help by offering advice on a structured and standardized approach to data collection with clear definitions of need and how this translates to workforce requirements. Evidence-based examples of how the integration of service and WFP can work to maximize the value provided by efficient use of health care budgets would also be useful. This can be supplemented by examples of defined models of service, evidence-based care pathways, and the effective deployment of skill mix, which can all feed into the planning process. Of course, the need to fill these current knowledge gaps should be supported by an expansion of applied research to develop and evaluate innovations in WFP.

## Conclusion

Most current approaches to WFP are not based on reliable methods to match workforce numbers to population needs through the estimation of the

services required to meet those needs. This review has identified some quantitative WFP models that aim to address population needs; however, the utility of these models relies on the existence and availability of the required data. Currently poor, or in some cases invalid, estimations or proxies of need are commonly used, and models of service are rarely defined. Similarly, methods to translate population needs to supply requirements, including skill mix, are underdeveloped. It is critical that information systems be developed to effectively capture data necessary to accurately plan future oral health care workforces.

## Author Contributions

L. O'Malley, contributed to conception, design, data acquisition, analysis and interpretation, drafted the manuscript; R. Macey, F. Thomson, contributed to data acquisition and analysis, critically revised manuscript; T. Allen, J. Rigby, G. Tomblin Murphy, contributed to data interpretation, critically revised the manuscript; P. Brocklehurst, R. Lalloo, S. Birch, contributed to conception, design, and data interpretation, critically revised the manuscript; M. Tickle, contributed to conception, design, and data interpretation, drafted the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

## Declaration of Conflicting Interests


The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

## ORCID iDs

R. Macey  <https://orcid.org/0000-0002-6071-5775>

R. Lalloo  <https://orcid.org/0000-0001-5822-1269>

G. Tomblin Murphy  <https://orcid.org/0000-0002-7305-7003>

## References

- Ab-Murat N, Sheiham A, Tsakos G, Watt R. 2015. Periodontal treatment needs and workforce requirements: comparisons between the normative and sociodental approaches using different skill mix models. *Community Dent Oral Epidemiol.* 43(2):106–115.
- Ab-Murat N, Sheiham A, Watt R, Tsakos G. 2015. Treatment needs and skill mix workforce requirements for prosthodontic care: a comparison of estimates using normative and sociodental approaches. *BMC Oral Health.* 15:36.
- Advisory Committee on Medical Manpower Planning. 2011. The 2010 recommendations for medical specialist training [accessed 2020 Oct 6]. [https://capaciteitsorgaan.nl/app/uploads/2016/01/2010\\_Recommendations-for-medical-spec-training\\_Netherlands.pdf](https://capaciteitsorgaan.nl/app/uploads/2016/01/2010_Recommendations-for-medical-spec-training_Netherlands.pdf).
- Ahern S, Woods N, Kalmus O, Birch S, Listl S. 2019. Needs-based planning for the oral health workforce—development and application of a simulation model. *Hum Resour Health.* 17(1):55.
- Ahmed A, Fateha B, Benjamin S. 2000. Demand and supply of doctors and dentists in Bahrain, 1998–2005. *La Rev Santé la Méditerranée Orient.* 6(1):6–12.
- Al-Jarallah K, Moussa M, Al-Duwairi Y, Zaatari E, Al-Khanfar K. 2010. The dentist workforce in Kuwait to the year 2020. *Community Dent Health.* 27(3):178–183.
- American Dental Association Health Policy Institute. 2017. State-level dentist workforce projections data and methods [accessed 2020 Nov 16]. <http://www.ada.org/~media/ADA/Science%20and%20Research/HPI/Files/HPIstateprojections.pdf>.
- Arrow KJ. 2004. Uncertainty and the welfare economics of medical care. 1963. *Bull World Health Organ.* 82(2):141–149.
- Bailit HL. 2017. How many dentists are needed in 2040: executive summary. *J Dent Educ.* 81(8):1015–1023.
- Beazoglou T, Bailit H, Heffley D. 2002. The dental work force in Wisconsin: ten-year projections. *J Am Dent Assoc.* 133(8):1097–1104.
- Beazoglou T, Heffley D, Brown LJ, Bailit H. 2002. The importance of productivity in estimating need for dentists. *J Am Dent Assoc.* 133(10):1399–1404.
- Birch S, Kephart G, Tomblin-Murphy G, O'Brien-Pallas L, Alder R, MacKenzie A. 2007. Human resources planning and the



- production of health: a needs-based analytical framework. *Can Public Policy*. 33 Suppl 1:S1–S16.
- Birch S, Tomblin Murphy G, MacKenzie A, Whittaker W, Mason T. 2017. Will the need-based planning of health human resources currently undertaken in several countries lead to excess supply and inefficiency? A comment on Basu and Pak. *Health Econ (United Kingdom)*. 26(6):818–821.
- Bourne CO, Sa B. 2012. Orthodontic treatment need of children in Trinidad and Tobago. *West Indian Med J*. 61(2):180–186.
- Brocklehurst P, Tickle M. 2012. Planning a dental workforce for the future for the National Health Service in the United Kingdom: what factors should be accounted for? *Health Educ J*. 71(3):340–349.
- Byck GR, Russinof H, Cooksey JA. 2002. Wisconsin dentist workforce report 2001 [accessed 2020 Jun 3]. <https://www.ihrp.uic.edu/files/WIDentistWorkforceReport.pdf>.
- Cao S, Gentili M, Griffin PM, Griffin SO, Harati P, Johnson B, Serban N, Tomar S. 2017. Estimating demand for and supply of pediatric preventive dental care for children and identifying dental care shortage areas, Georgia, 2015. *Public Health Rep*. 132(3):343–349.
- Cartes-Velásquez RA. 2013. Exponential growth of dental schools in Chile: effects on academic, economic and workforce issues. *Braz Oral Res*. 27(6):471–477.
- Cooksey J, Byck G. 2000. Dental requirements model (DRM): forecasting the dentist requirements for low-income children. Washington (DC): Federal Forecasters Conference [accessed on 2020 Nov 16]. <https://files.eric.ed.gov/fulltext/ED455316.pdf>
- Department of Health. 2004. Report of the primary care dental workforce review [accessed on 2020 Nov 16]. <https://hansard.parliament.uk/Commons/2004-07-22/debates/f7561e1f-3b7a-4217-a2c1-2ca36913fe06/PrimaryCareDentalWorkforceReview>
- Department of Health, Higher Education Funding Council for England. 2012. The Health and Education National Strategic Exchange (HENSE) review of medical and dental school intakes in England [accessed on 2020 Nov 16]. <https://dera.ioe.ac.uk/16155/>
- De Silva MDK. 2012. Dental workforce planning for Sri Lanka [dissertation]. Southampton (UK): University of Southampton.
- Doughan B, Kassak K, Bourgeois D. 2005. Planning dental manpower in Lebanon: scenarios for the year 2015. *East Mediterr Health J*. 11(5–6):943–951.
- Gallagher JE, Kleinman ER, Harper PR. 2010. Modelling workforce skill-mix: how can dental professionals meet the needs and demands of older people in England? *Br Dent J*. 208(3):E6.
- Gallagher JE, Lim Z, Harper PR. 2013. Workforce skill mix: modelling the potential for dental therapists in state-funded primary dental care. *Int Dent J*. 63(2):57–64.
- Gallagher JE, Manickam S, Wilson NHF. 2015. Sultanate of Oman: building a dental workforce. *Hum Resour Health*. 13:50.
- Guthrie D, Valachovic RW, Brown LJ. 2009. The impact of new dental schools on the dental workforce through 2022. *J Dent Educ*. 73(12):1353–1360.
- Harper P, Kleinman E, Gallagher J, Knight V. 2015. Cost-effective workforce planning: optimising the dental team skill-mix for England. *J Enterp Inf Manag*. 26(1/2):91–108.
- Health Workforce Australia. 2014. Australia's future health workforce—oral health: detailed report [accessed on 2020 Nov 16]. [https://www1.health.gov.au/internet/main/publishing.nsf/Content/3CFAE9DEE7BB7659CA257D9600143C09/\\$File/AFHW%20-%20Oral%20Health%20Overview%20report.pdf](https://www1.health.gov.au/internet/main/publishing.nsf/Content/3CFAE9DEE7BB7659CA257D9600143C09/$File/AFHW%20-%20Oral%20Health%20Overview%20report.pdf).
- Huang CS, Cher TL, Lin CP, Wu KM. 2013. Projection of the dental workforce from 2011 to 2020, based on the actual workload of 6762 dentists in 2010 in Taiwan. *J Formos Med Assoc*. 112(9):527–536.
- Jäger R, Van Den Berg N, Hoffmann W, Jordan RA, Schwendicke F. 2016. Estimating future dental services' demand and supply: a model for Northern Germany. *Community Dent Oral Epidemiol*. 44(2):169–179.
- Levac D, Colquhoun H, O'Brien K. 2010. Scoping studies: advancing the methodology. *Implement Sci*. 5(1):69.
- Lexomboon D, Punyasingh K. 2000. Supply projections for dentists, Thailand (2000–2030). *Human Resource for Health Development Journal*. 4(2):94–105.
- McPake B, Maeda A, Araújo EC, Lemiere C, El Maghraby A, Cometto G. 2013. Why do health labour market forces matter? *Bull World Health Organ*. 91(11):841–846.
- National Leadership and Innovation Agency for Healthcare. 2012. An analysis of the dental workforce in Wales [accessed on 2020 Nov 16]. <http://www.wales.nhs.uk/sitesplus/documents/829/Analysis%20of%20Dental%20Workforce%20Wales%202012%20Full%20Report.pdf>.
- NHS Education for Scotland. 2008. An analysis of dental workforce in Scotland [accessed on 2020 Nov 16]. <http://www.scottishdental.org/wp-content/uploads/2014/07/An-Analysis-of-Dental-Workforce-in-Scotland-2008.pdf>.
- Oh Y. 2011. The future prospects of demand and supply of health workforce in Korea. Yeongi-gun (South Korea): Personal communication.
- Royal College of Surgeons of England. 2005. Developing a modern surgical workforce. London (UK): Royal College of Surgeons [access 2020 Nov 18]. <https://www.rcseng.ac.uk/library-and-publications/rcs-publications/docs/developing-a-modern-surgical-workforce/>.
- Saman DM, Arevalo O, Johnson AO. 2010. The dental workforce in Kentucky: current status and future needs. *J Public Health Dent*. 70(3):188–196.
- Schwendicke F, Jäger R, Hoffmann W, Jordan RA, van den Berg N. 2016. Estimating spatially specific demand and supply of dental services: a longitudinal comparison in Northern Germany. *J Public Health Dent*. 76(4):269–275.
- Shaw JL. 2015. Allocation of dentists to Canadian Armed Forces dental clinics: a comparison between two human resource planning models [dissertation]. Toronto (Canada): University of Toronto.
- Shaw JL, Farmer JW, Coyte PC, Lawrence HP. 2017. Comparing human resource planning models in dentistry: a case study using Canadian Armed Forces dental clinics. *Community Dent Oral Epidemiol*. 45(3):209–215.
- Spencer A J, Teusner DN, Carter KD, Brennan DS. 2003. The dental labour force in Australia: the position and policy directions. Canberra (Australia): Australian Institute of Health and Welfare and the Australian Research Centre for Population Oral Health [accessed 2020 Nov 18]. <https://www.aihw.gov.au/getmedia/061fa81d-ce73-40e3-b702-3b165a8565eb/labourforce-directions.pdf.aspx?inline=true>
- Teusner DN, Chrisopoulos S. 2008. Dentist labour force projections 2005 to 2020: the impact of new regional dental schools. *Aust Dent J*. 53(3):292–296.
- Tira DE, Peters RI, Reed MJ, Killip JW. 2003. Addressing dental workforce issues in Missouri and Kansas: one school's initiative. *J Dent Educ*. 67(8):902–908.
- Try G. 2000. Too few dentists? Workforce planning 1996–2036. *Prim Dent Care*. 7(1):9–13.

- US Department of Health and Human Services. 2015. Community catalyst: national and state-level projections of dentists and dental hygienists in the US, 2012–2025. Boston (MA): US Department of Health and Human Services [accessed 2020 Nov 18]. <https://www.communitycatalyst.org/initiatives-and-issues/initiatives/dental-access-project/National-and-State-Level-Projections-Summary-1.pdf>.
- Vundavalli S. 2014. Dental manpower planning in India: current scenario and future projections for the year 2020. *Int Dent J*. 64(2):62–67.
- Wanyonyi KL, Radford DR, Harper PR, Gallagher JE. 2015. Alternative scenarios: harnessing mid-level providers and evidence-based practice in primary dental care in England through operational research. *Hum Resour Health*. 13:78.
- Whittaker W, Birch S, MacKenzie A, Murphy GT. 2016. Cohort effects on the need for health care and implications for health care planning in Canada. *Health Policy*. 120(1):81–88.